

EXPERIMENTAL AERODYNAMICS

VI Semester: AE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAE509	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45		Tutorial Classes: 0		Practical Classes: Nil			Total Classes: 45	
OBJECTIVES:								
The course should enable the students to:								
I. Describe basic fundamentals of Aerodynamics experiments, their need in comparison with numerical computation and theoretical studies.								
II. Develop concepts of flow similarity and evaluate the loss coefficients of wind tunnel components.								
III. Analyze the concept of force and moment measurements using wind tunnel balance and extrapolate it to new balance development.								
IV. Summarize various techniques for pressure, velocity, temperature measurement and flow visualization.								
COURSE OUTCOMES (COs)								
CO 1 Understand the fundamental need of Experimental Aerodynamics and various types of wind tunnels and their applications.								
CO 2 Understand various wind tunnel design criteria of each parts, losses and corrections.								
CO 3 Interpret the various model mounting techniques and load computation								
CO 4 Understand the basic construction structures of sensors and measuring techniques								
CO 5 Evaluate the Flow visualization techniques for low speed and high speed aerodynamics								
COURSE LEARNING OUTCOMES (CLOs):								
1. Wind tunnel experimental test and measuring techniques								
2. Development of wind tunnel experimental test								
3. Types of Wind tunnels and their requirements will help the students to design and application								
4. Wind tunnels for industrial and various applications apart from aerospace requirements								
5. Requirements for quality assurance in testing methodology								
6. Experimental requirements and design constraints								
7. Wind tunnel quality and performance								
8. Source of errors and correction methodology								
9. Usage and need of wind tunnel balance								
10. Models mounting techniques								
11. Various techniques used in wind tunnels for flow visualization								
12. Schlieren system and set up								
13. Merits and demerits of various flow visualization techniques								
14. Right tools and techniques for required flow speed								
15. Flow measurements techniques for steady								
16. Flow measurements techniques for unsteady flow								
17. Usage of electronic device and transducer,								
18. Usage of hot wire Anemometry								
19. Usage of electronic device and transducer								
20. Flow visualization technique for subsonic and supersonic flow								
UNIT-I	FUNDAMENTALS OF EXPERIMENTS IN AERODYNAMICS						Classes: 08	

Forms of aerodynamic experiments, observations, measurement objectives. History: Wright Brother's wind tunnel, model testing, wind tunnel principles, scaling laws, scale parameters, geometric similarity, kinematic similarity & dynamic similarity. Wind tunnels: low speed tunnel, high speed tunnels, transonic, supersonic and hypersonic tunnels, shock tubes. Special tunnels: low turbulence tunnels, high Reynolds number tunnels, environmental tunnels, automobile tunnels, distinctive features, application.		
UNIT -II	WIND TUNNEL EXPERIMENTATION CONSIDERATIONS	Classes: 08
Low speed wind tunnels, principal components. Function, description, design requirements, constraints and loss coefficients. Wind tunnel performance flow quality, power losses, wind tunnel corrections, sources of inaccuracies: buoyancy, solid blockage, wake blockage, streamline curvature causes, estimation and correction.		
UNIT-III	WIND TUNNEL BALANCE	Classes: 09
Load measurement: low speed wind tunnel balances, mechanical & Strain gauge types, null displacement methods & strain method, sensitivity, weigh beams, steel yard type and current balance type, balance linkages, levers and pivots. Model support three point wire support, three point strut support, platform balance, yoke balance, strain gauge, 3-component strain gauge balance, description, application.		
UNIT-IV	PRESSURE, VELOCITY & TEMPERATURE MEASUREMENTS	Classes: 10
Pressure: static pressure, surface pressure orifice, static probes, pitot probe for total pressure, static pressure and flow angularity, pressure sensitive paints, steady and unsteady pressure measurement and various types of pressure probes and transducers, errors in pressure measurement. Temperature: measurement of temperature using thermocouples, resistance thermometers, temperature sensitive paints and liquid crystals. Velocity: measurement of airspeed, Mach number from pressure measurements, flow direction, boundary layer profile using pitot static probe, 5 hole probe yaw meter, total head rake, hot wire anemometry, laser doppler anemometry, particle image velocimetry, working principle description of equipment, settings, calibration, measurement, data processing, applications.		
UNIT-V	FLOW VISUALIZATION TECHNIQUES	Classes: 10
Flow visualization: necessity, streamlines, streak lines, path lines, time lines, tufts, china clay, oil film, smoke, hydrogen bubble. Optical methods: density and refractive index, schlieren system, convex lenses, concave mirrors, shadowgraph, interferometry, working principle, description, setting up, operation, observation, recording, interpretation of imagery, relative merits and applications.		
Text Books:		
<ol style="list-style-type: none"> 1. Jewel B Barlow, William H Rae Jr. & Alan Pope, —Low Speed Wind Tunnel Testing, John Wiley & Sons Inc, Re-Print, 1999. 2. Alan Pope, Kenneth L Goin, —High Speed Wind Tunnel Testing, John Wiley & Sons, Reprint, 1965. 		
Reference Books:		
<ol style="list-style-type: none"> 1. Gorlin S M & Slezinger I I, —Wind tunnels & Their Instrumentations, NASA publications, Translated version, 1966. 2. Jorge C Lerner & Ulfilas Boldes, —Wind Tunnels and Experimental Fluid Dynamics Research, InTech, 1st Edition, 2011. 3. Liepmann H W and Roshko A, —Elements of Gas Dynamics, John Wiley & Sons, 4th Edition, 2003. 		
Web references:		
<ol style="list-style-type: none"> 1. https://nptel.ac.in/courses/101106040/ 2. https://ocw.metu.edu.tr/course/view.php?id=66 3. https://www.mace.manchester.ac.uk/our-research/research-themes/aerospaceengineering/specialisms/aerodynamics/ 4. https://www.ara.co.uk/services/experimental 5. https://soliton.ae.gatech.edu/labs/windtunl/ 		
E-Text Books:		

1. <https://www.scribd.com/doc/221788571/Wind-Tunnel-Testing-Barlow-Rae-Pope>
2. <https://www.scribd.com/document/84868596/Wind-Tunnelsibooksonline.com/library/view/data-structures-using/9789332524248/>